FLOOD AND BANK EROSION STUDY

Fort Vermilion, Alberta

March, 1968

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STUDY

Fort Vermilion, Alberta

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Lloyd Sadler = 425-1130

Subservice drainage
$400 to $1,000 per acre

March, 1968

Hydrology Branch
Alberta Water Resources Division

INDEX

INTRODUCTION

1.1 As requested by the Department of Municipal Affairs in two separate memorandums dated June 9, 1967 (Appendix D), the Hydrology Branch has carried out a study on the Peace River at Fort Vermilion. This study attempted to: 1. describe what areas are, or might be subject to flooding, 2. estimate the stability of the right bank adjacent to this settlement, and 3. estimate the feasibility of locating a major road along the edge of this right bank.

GENERAL DESCRIPTION OF AREA

2.1 The location of the Fort Vermilion settlement is shown in Figure 1 to be in the southern half of Township 108, Ranges 12 and 13, west of the fifth meridian. Figure 2 shows the settlement extending from point A (which is the north-west corner of the Federal Government Agriculture Experimental Station) to point B (which is the western edge of the airport).

The area of primary concern to the Department of Municipal Affairs is that area outlined in red (Figure 2). It is in this area that the major amount of residential development has occurred to-date.

2.2 Referring to Figure 2, the Peace River is shown confined to a single 1700 foot channel two miles west of Fort Vermilion. In contrast, the reach adjacent to the settlement shows that the river can operate in two and sometimes three channels. Figure 3 shows the approximate bankfull widths of the river's channels at various sections.

2.3 In general, the bankfull elevation of the right bank (i.e. elevation above which land adjacent to the river could be called flood-plain area) varies from about 910 (Geodetic) at point A (Figure 2) to 830 (Geodetic) point B, about 3 miles downstream. The right bank is covered with a thick growth of poplar and willows in the reach adjacent to the agriculture farm. This tree growth becomes sparser towards the airport. Photographs 3 to 5 show the right bank adjacent to the business area of Fort Vermilion and it can be seen that there is not much in the way of tree growth in

this area. Further east from this area, as far as the airport, the vegetation on the right bank is similar to that shown in Photograph 3.

2.4 The drainage area of the Peace River to Fort Vermilion, is approximately 86,000 square miles. Figure 1 shows the type of terrain making up the drainage area southwest of Fort Vermilion. This topographic map indicates that the area between Peace River and Fort Vermilion would be poorly drained due to the large percentage of muskeg land.

HYDROLOGY

3.1 There is presently a Federal Government hydrometric station (No. 7HF-1) located at the ferry crossing two miles west of Fort Vermilion (point C, Figure 2). It has been in operation continuously since 1961. Previous to this, summer flows were measured from 1915 to 1922. Therefore, recorded data are very limited in extent, and this can be attributed to the isolated location of Fort Vermilion.

3.2 Flood-frequency analysis: Flood peaks for the above two periods of record are tabulated in Table 1. A statistical test indicated that it would be reasonable to combine the 1915 to 1922 and post 1961 records for the purpose of a flood frequency analysis. This was done and the results were plotted on log-normal probability paper (Figure 4). The plotted points show a good fit to a straight line.

One very disconcerting fact arises when comparing flood peaks for any one flood and year at Peace River and Fort Vermilion. The Peace River flood peaks are listed beside those for Fort Vermilion, Table 1. When comparing the two columns of data, one will find that the peak events at Fort Vermilion measured from 1915 to 1922 are consistently higher than those upstream at Peace River. On the other hand comparison of the after 1961 flood events show flood peaks at Fort Vermilion are consistently lower than at Peace River.

Logically, one would expect that because Fort Vermilion is about 175 miles downstream from Peace River, with tributaries in-between adding to the size of a particular flood, then the flood peaks at Fort Vermilion should be higher. Therefore, the first few years of data would seem

reasonable. However, one would tend to have more confidence in the more up-to-date measurements. The recent data could be considered reasonable from the point of view that the drainage between Peace River and Fort Vermilion is poorly drained and would not necessarily be producing large volumes of runoff at the same time that the headwaters area is. This together with the occurrence of a lot of channel storage between Peace River and Fort Vermilion, could for a given flood mean smaller flood peaks at Fort Vermilion.

The conflicting situation above indicates that either; 1. Fort Vermilion discharge measurements from 1915 to 1922 were too conservative, 2. Peace River discharge measurements have been consistently too high, 3. the post 1961 flood peak estimates have been too low, or 4. there has been a change in climate in the last fifty years which has resulted in lower runoff volumes between Peace River and Fort Vermilion. Because of the above doubts placed on some parts of the discharge records at Fort Vermilion, it was decided to derive a flood-frequency curve for Fort Vermilion in some other manner than presented in Figure 4.

3.3 W.A.C. Bennett Dam: Compounding the difficulty in obtaining a good flood-frequency curve for Fort Vermilion is the future effect on Peace River flows by the W.A.C. Bennett Dam. This dam will effectively control runoff from about 27,000 square miles of the upstream end of the Peace River drainage basin. Location of this dam is shown in Figure 5. That portion of the basin from which reservoir water will be derived is the headwater area, from which the majority of water carried by the Peace River is obtained. For example, during the 1963-64 water year, the total volumes of runoff passing Hudson Hope, Peace River and Fort Vermilion were

37,170,000 acre-feet, 66,780,000 acre-feet and 67,880,000 acre-feet respectively. On a unit runoff basis the drainage area upstream of Hudson Hope produced 1376 acre-feet of runoff per square mile. Between Hudson Hope and Peace River, and then Peace River and Fort Vermilion, the unit runoff for 1963-64 were 680 acre-feet per square mile and 67 acre-feet per square mile respectively. These results show just how little runoff is derived for the Peace River from the drainage area between the settlement and Peace River.

Reservoir Operation: Construction of the W.A.C. Bennett Dam is just being completed, and filling of the reservoir will begin in the spring of 1968. The proposed schedule of reservoir operation is shown in Figure 6. Power generation is expected to commence October 1, 1968. According to regulations stipulated in the water license, reservoir operation will require that:

1. The maximum quantity of water which may be stored is 32,000,000 acre-feet per year (not water year)
2. From December 1 to March 31, the minimum flow to be maintained immediately below the dam by releases from the reservoir is the calculated natural inflows to the reservoir.
3. From April 1 to July 15, the minimum flow to be released shall be 10,000 cubic feet per second, or the natural flow, whichever is the lesser, as measured at Taylor, B.C.
4. From July 16 to September 15, this minimum flow shall be 10,000 cubic feet per second, as measured at Hudson Hope, B.C.
5. From September 16 to November 30, minimum flow to be maintained shall be 10,000 cubic feet per second or the natural flow, whichever

is the lesser, as measured at Taylor, B.C.

6. A flow of not less than 1,000 cubic feet per second shall be released from the dam at all times.

The above regulations express minimum flows and would be in effect only during extremely dry summers and winters. During average or above average floods the main effect of the dam would be on the flood peaks, which may be expected to be dampened considerably. *For instance, it is expected that a flood peak inflow to the reservoir of 650,000 c.f.s. would have a dampened or modified outflow of 300,000 c.f.s. A flood of 650,000 c.f.s. is considered the maximum probable peak. Therefore, it would be expected that smaller floods than this would be modified proportionately more. The amount of modification of a flood peak would obviously depend upon the initial amount of live storage in the reservoir.

It is expected that the extreme flood will occur consequently to the melting of the winter snowfall, when the reservoir should have its lowest elevation of the year by reason of winter power generation demands on storage, as well as the ability to predict from snow course measurements the anticipated flood volume. The above estimates of what amount the maximum probable flood would be modified, was calculated assuming the reservoir would be at its highest post-winter level according to the operation curve of Figure 6.

3.4 Flood-frequency curve: An attempt has been made to produce a theoretical flood-frequency curve for the Peace River flood peaks at Fort Vermilion. Cognizance has been taken of not only a lack of good discharge data at Fort Vermilion, but also the impending effect of the Bennett Dam.

* Information obtained from B.C. Department of Lands, Forests and Water Resources

Construction of this theoretical curve was attempted in two ways, and an explanation follows.

Method 1.

Flood-frequency curves were drawn from discharge records for four hydrometric stations at Findlay Forks, Hudson Hope, Taylor, B.C. and Peace River, Alberta. These curves are shown in Figures 7 to 10. A plot of drainage area versus flood peaks for various return periods was made and curves were extrapolated to the Fort Vermilion drainage area of 87,000 square miles.

Taking the difference between the discharges at Hudson Hope (27,800 square miles) and Fort Vermilion, for various return periods, from Figure 11, a flood-frequency curve was drawn for the drainage area between Hudson Hope and Fort Vermilion (Figure 12, curve 1). The flood-frequency for Hudson Hope is redrawn on Figure 13, curve 1. It was then assumed that the extreme flood peaks would be dampened at least 50% by the reservoir, and this adjustment was assumed constant and is shown as curve 2 on Figure 13. In all likelihood this curve should be steeper, as the smaller peaks would be modified by even more than 50%. However, it would be impossible at this point to estimate what the actual slope should be. Therefore, drawing curve 2 at the slope shown probably provides an overestimate of floods for any given return period.

The adjusted flood-frequency curve for Hudson Hope was then plotted on top of curve 1, Figure 12, and the result is shown as curve 2. This curve is assumed one possibility for the theoretical flood-frequency curve at Fort Vermilion.

Method 2.

The second method involved using an adjusted drainage area and the relationship $Q_{100} = KA^{.8}$

a. At Taylor, B.C.

$Q_{100} = 440,000$ c.f.s. ; $A = 38,300$ miles^2

$$K = \frac{440,000}{(38,300)^{.8}} = 96$$

At Peace River, Alberta

$$Q_{100} = \frac{540,000}{(72,000)^{.8}} = 70$$

From a plot of K versus A Figure 14, a K value of 50 is estimated for the Peace River at Fort Vermilion.

b. The K value at Hudson Hope is taken as 94, also from Figure 14, and Q_{100} is taken as 300,000 c.f.s. Now, due to the modifying effect of the Bennett Dam the 100 year flood immediately below the dam will be taken as 150,000 c.f.s.

$150,000 = 94\ Ae^{.8}$ where Ae will be called the effective area.

$$\text{Now } Ae = \left(\frac{150,000}{94}\right)^{1/.8} = 10,000 \text{ miles}^2$$

Since the area between Hudson Hope and Fort Vermilion is 58,200 miles^2, the net effective area at Fort Vermilion is 10,500 miles^2 + 58,200 miles^2 = 68,500 miles^2

Using $Q_{100} = 50\ Ae^{.8}$ at Fort Vermilion, it is found that:

$$Q_{100} = 50 \times 68,500^{.8} = 370,000 \text{ c.f.s.}$$

This value of Q_{100} was plotted on Figure 15, and a frequency-curve was drawn through this point assuming a similar slope as the Peace River frequency-curve. Again, this curve should probably be steeper because the Bennett Dam would completely control the smaller floods, but there are presently not enough facts to estimate the correct slope. This second theoretical flood frequency-curve for Fort Vermilion is shown as curve 1 on Figure 15.

From Figure 15 it can be observed that the two theoretical frequency-curves for Fort Vermilion are fairly close at the lower frequencies but quite dissimilar for the lower flood peaks. The frequency-curve defined on curve 1, Figure 15, will be used for analysis in this report, as it is felt that it is the more correct one.

HISTORY

4.1 A few residents in Fort Vermilion were questioned about past floods they have witnessed there. The more important information obtained is summarized below.

1. Mrs. Rivard; has lived in Fort Vermilion since 1917. The worst flood in her memory occurred in 1934, when an ice-jam downstream from Fort Vermilion caused flood waters to overflow its banks at the settlement. This ice-jam occurred where the Peace River divides into three channels, two miles below Fort Vermilion.

   It is estimated that there was one foot of water at the theatre corner, and two feet at the Hudson Bay Co. store, points A and B respectively, Figure 16.

   She had heard that an 1888 flood was just as bad as the 1934 flood.

2. Mrs. Clarke; a resident in Fort Vermilion since 1933, estimates that there was six feet of water in the 1934 flood where the airport is now located. She cannot remember a worse flood since 1934, although there were two occasions since then (one being 1963 or 1964) when the airport area road had two feet of water over it.

   Water reached the base of the B and B Motel restaurant (point C, Figure 16), in the 1934 flood.

3. Mr. Kidd; a resident in Fort Vermilion since 1920, remembers that the 1934 flood caused water to be six feet deep about three

hundred feet east of the Hudsons Bay Co. store. The flood waters affected the flood plain area to a distance of 300 feet back of the right bank.

The river reached bankfull in 1964.

4.2 Some photographs were obtained of the 1934 flood, and these are shown on page C-1.

The first photograph shows the flood waters in the flood plain adjacent to the right bank, and in the background, the jamming of ice can be noted. As closely as could be determined this photograph was taken looking downstream from point D, Figure 16.

The second photograph indicates what tremendous forces must be at work during ice jams. This photograph was taken about one-half mile upstream of the first one, or at about point E, Figure 16.

SURVEYS

5.1 Surveys were carried out in order to obtain some physical measure of the Peace River channel adjacent to the Fort Vermilion settlement. Figure 17 outlines the various lines surveyed where; line 1 is a profile survey of the top of the right bank, line 2 is an ice surface and bed profile survey of the main channel, and line 3 is an ice surface and bed profile survey of the secondary channel. In addition, the red lines indicate the approximate location of sections which were surveyed.

5.2 Figure 18 shows the plotted results of the profile surveys. All elevations are referred to Geodetic.

Figures 19 and 20 show the two cross-sections which were chosen to be used for computing stage-discharge curves.

STAGE - DISCHARGE CURVES

6.1 Stage-discharge curves were made up for two cross-sections. The first stage-discharge relationship is for a cross-section located about where cross-section 1 is shown on Figure 17, while the second one is located about where cross-section 4 is shown.

It proved quite difficult to estimate discharges at these cross-sections because, as can be noted from Figure 2, the Peace River adjacent to Fort Vermilion can operate in more than one channel. Methods used for calculating discharges were fairly crude due mainly to assumptions made for simplifying the computations.

6.2 The derived stage-discharge curves are drawn in Figure 21.

FLOODS IN FORT VERMILION

7.1 Figure 18 includes a profile of the top of the right bank, adjacent to the Fort Vermilion settlement. It shows that the bankfull elevation along the business section (station 40+00 to 80+00) varies from 841 to 837. Bankfull elevations decrease downstream from 80+00, and reaches a minimum of about 830 at station 125+00 (point D, Figure 2). A bankfull elevation at the west end of the airport (about station 155+00) has been established at about 837.

7.2 Using information derived from interviews with Fort Vermilion residents, (section 4), the following Geodetic flood elevations have been assembled.

	1934 Flood at	Elevation
1.	Point A, Figure 16	842.0
2.	Point B, Figure 16	843.0
3.	Airport area, Point B, Figure 2	843
	1964 Flood at	Elevation
1.	Airport area	839

The pattern of flooding in Fort Vermilion can be roughly established. Water would initially top the right bank in the area of point D, (Figure 2), and because land west of this point generally has an upward slope, the land affected would tend to move westward as the flood elevation continued to rise above 830. This point is confirmed somewhat as during the 1934 flood, water was described as being six feet deep at the airport and only a foot or so, two miles west in the densely settled area of Fort Vermilion.

Probable extent of the 1934 flood is outlined in red on Figure 16. As the first photograph on page C1 shows, the area east of that shown in Figure 16, was also under water at this time.

7.3 Frequency of Flooding: There are two separate types of flood action which must be considered here; 1. water ponding up behind an ice jam and causing unnaturally high water to spill over the banks, and 2. flooding occurring without the presence of ice jams. Obviously a flood event of the first type is the one of main concern since even moderate floods could cause serious flooding if the channel were partially blocked by ice. For example, the 1934 flood which reached a crest of about 843 aided by an ice jam, would seemingly have a discharge in excess of 750,000 c.f.s. (according to Figure 18) if an ice jam was not occurring. The "natural" flood frequency curve given in Figure 4 indicates that this size of flood would have a return period of much greater than 10,000 years. If one were to take into account the Bennett Dam and use the frequency curve of Figure 15, then a flood peak of 750,000 c.f.s. would even be rarer if not impossible. Therefore, it is probably safe to say that the 1934 flood elevation will never be reached again by anything other than by flood waters backed-up by ice jams. Using Figures 21 and 15, it can be predicted that under normal flood flow conditions (i.e. no ice jams), bankfull discharge at a section just downstream of cross-section 4, (about station 125+00, Figure 18) will be reached at a discharge of about 400,000 c.f.s., which has a probability of occurring once every 200 years. This would provide the minimum flood condition along the Fort Vermilion settlement at a location two miles east of its developed area where the local land

elevation may be ten feet lower.

7.4 Ice jams: The occurrence of an ice jam would be an impossible thing to predict in advance. It can only be said that ice jams have been responsible for one serious flood in 1934 and possibly a second one in 1888. The W.A.C. Bennett Dam will have the effect of modifying to quite an extent future flood peaks, but this is no guarantee that serious ice jams will occur with less frequency.

It is believed that ice jamming originates in that reach of river north of the airport (point E, Figure 2). Here the river channel expands considerably, and this would have the effect of reducing the velocity of flow. This decrease in velocity, coupled with sudden changes in direction of flow, would cause the ice to move sluggishly and possibly pile up in the area of point E (Figure 2). Serious ice jamming would occur under certain undefined climatic and hydraulic conditions.

7.5 Construction of dyke: Since flooding problems probably begin at point D (Figure 2), it might prove feasible to construct a dyke along the right bank between stations 90+00 and 150+00. This dyke would have a crest elevation of about 840 (Geodetic). It is not possible to confidently assign a design return period to this elevation because as mentioned above, it is the high water caused by unpredictable ice jams that is being designed for.

Further field surveys would be necessary to arrive at a more definite design for the dyke.

BANK EROSION

8.1 An opinion expressed by one individual interviewed in Fort Vermilion was, that about twelve feet of bank have been lost to erosion, in front of the Hudsons Bay Co. Store (point H, Figure 16) since 1948. Another old-timer estimated that ten feet of bank has been eroded in front of the Hudson Bay Co. store in the last fifty-five years. Photographs of this area are shown on page C-2. They show that this length of bank is distinguishable by its lack of tree growth.

A few measurements were taken from old survey posts to the right bank's edge. These posts were placed during the original government survey of the settlement in 1898 and 1906. There were few of these posts remaining and only two measurements were made.

1. From a post on the north-west corner of H.B.C. property (near point D, Figure 16) to bank, was measured as 100 feet. Original measurements had this distance measured as about 100 feet, so apparently little bank erosion has occurred here.
2. From a post to bank-edge at the north-east corner of Hudsons Bay Co. store (near point H, Figure 16) was measured as 59 feet. Original measurements had this distance measured as 80 feet which indicates that about 21 feet of bank has eroded since 1906.

From comparisons of airphotos and old survey maps, it was concluded that there has been little loss of right bank due to erosion, between the airport and point D, Figure 16. Possibly this could be attributed to the expanding flow in this reach,

and the fact that the alignment of the main channel is straight.

8.2 It appears that the main area where active bank erosion is occurring is in front of the Hudsons Bay Company store. Photographs show that the length of this eroding reach is about three hundred feet long.

This bank erosion will continue at its slow rate of about one-third of a foot per year and if it is proposed to construct a main road adjacent to this reach, then some form of bank protection should be considered. In the remainder of that length of right bank from point A to B, Figure 2, some small amount of erosion is taking place but at a very slow rate. Test holes taken in a survey in 1967 indicate that shale may be outcropping along the right bank, and its presence would partly explain the slow rate at which the right bank is eroding.

CONCLUSIONS

9.1 If any part of the Fort Vermilion settlement is again flooded, the flooding action will most likely be accompanied by an ice jam originating in that length of the Peace River north of the airport.

9.2 The land between the airport and the east edge of the area shown on Figure 16 is more liable to flooding action because of its generally lower position in the flood plain.

9.3 The 1934 flood is the worst in memory and its probable extent of flooding in the area shown by Figure 16, is shown there bounded by a red line. It is impossible to assign a probability of recurrence of this flood.

9.4 Regardless of the modifying effects of the W.A.C. Bennett Dam on flood peaks, a repeat of the 1934 flood is possible if a serious enough ice jam occurs.

9.5 A dyke along the right bank, extending one mile upstream of the airport, and having a crest elevation of 840, is one means of possibly safe-guarding the Fort Vermilion settlement from some future floods.

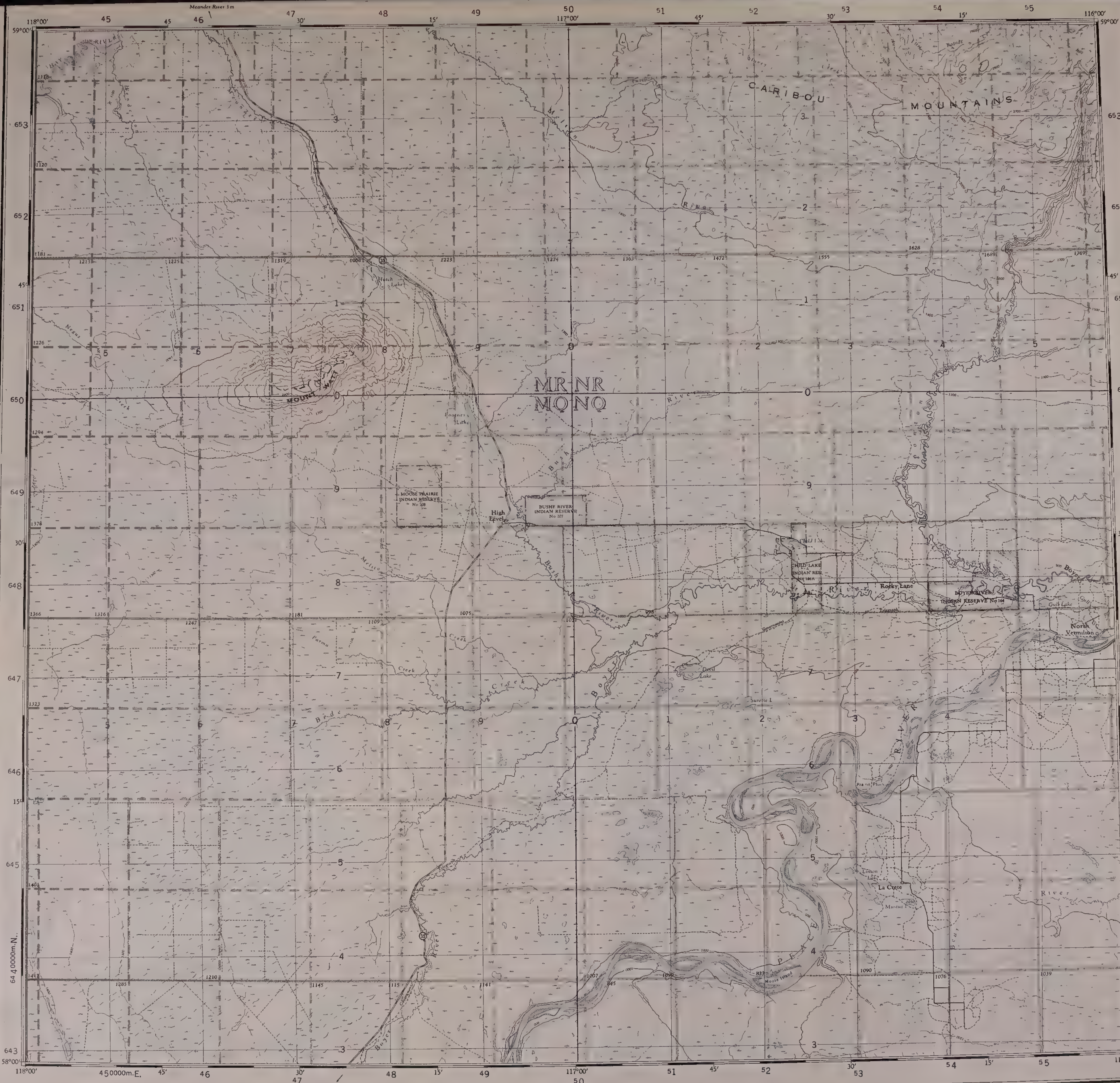
9.6 Bank erosion is presently occurring in front of the Hudsons Bay Co. store at a rate of about one-third of a foot per year, along a three hundred foot length of right bank. Some bank protection should be considered here if a main roadway is being contemplated adjacent to it.

9.7 The remaining length of right bank along the settlement may be

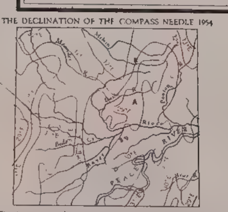
eroding but at very slow rate, probably because of some shale outcropping along this bank.

APPENDIX A

FIGURES



THE DECLINATION OF THE COMPASS NEEDLE 1954



Produced and printed by the SURVEYS AND MAPPING BRANCH, DEPARTMENT OF MINES AND TECHNICAL SURVEYS, 1958.

Universal Transverse Mercator Projection

Contour interval 100 Feet
Elevations in Feet above Mean Sea Level
North American Datum 1927

MOUNT WATT

ALBERTA

WEST OF FIFTH MERIDIAN

Scale 1:250,000

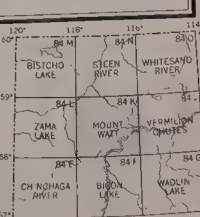
1 Inch to 4 Miles Approximately

REFERENCE

Roads
hard surface, all weather — more than 2 lanes — 2 lanes — less than 2 lanes
loose surface, all weather — 2 lanes or more — less than 2 lanes — dry weather
wagon, cart track — Trail or cut line
Railway, normal gauge — multiple track — single track — abandoned — Station — Tagging
Boundaries: international, provincial, Indian reserve, park, etc., township surveyed, township unsurveyed, section line
Contours: elevation, depression, approximate
Spot elevation (in feet)
Power transmission line
Telephone line

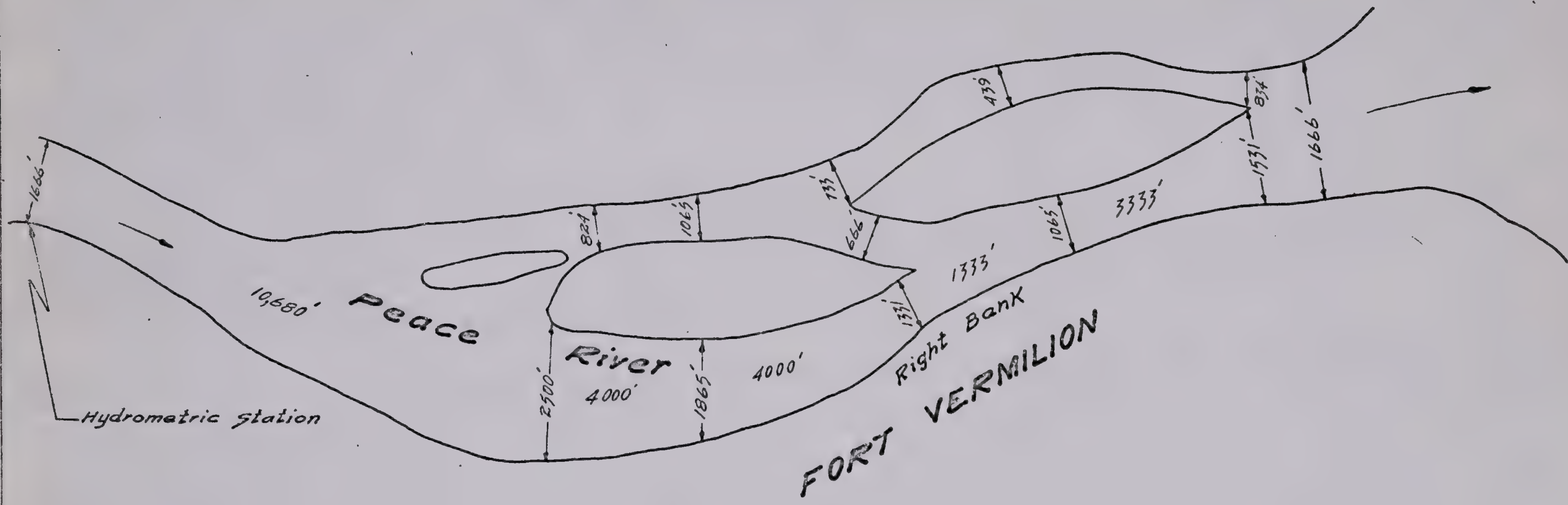
REFERENCE

Town — School
Village or settlement — Church
Post office — Building or cabin
Streams: intermittent or dry, indefinite — Intermittent lake
Marsh or swamp
Sand, gravel or mud
Rapids, falls — Seaplane base
Aerodrome — Seaplane anchorage
Landing ground — Wooded areas not shown



Index to Adjoining Sheets

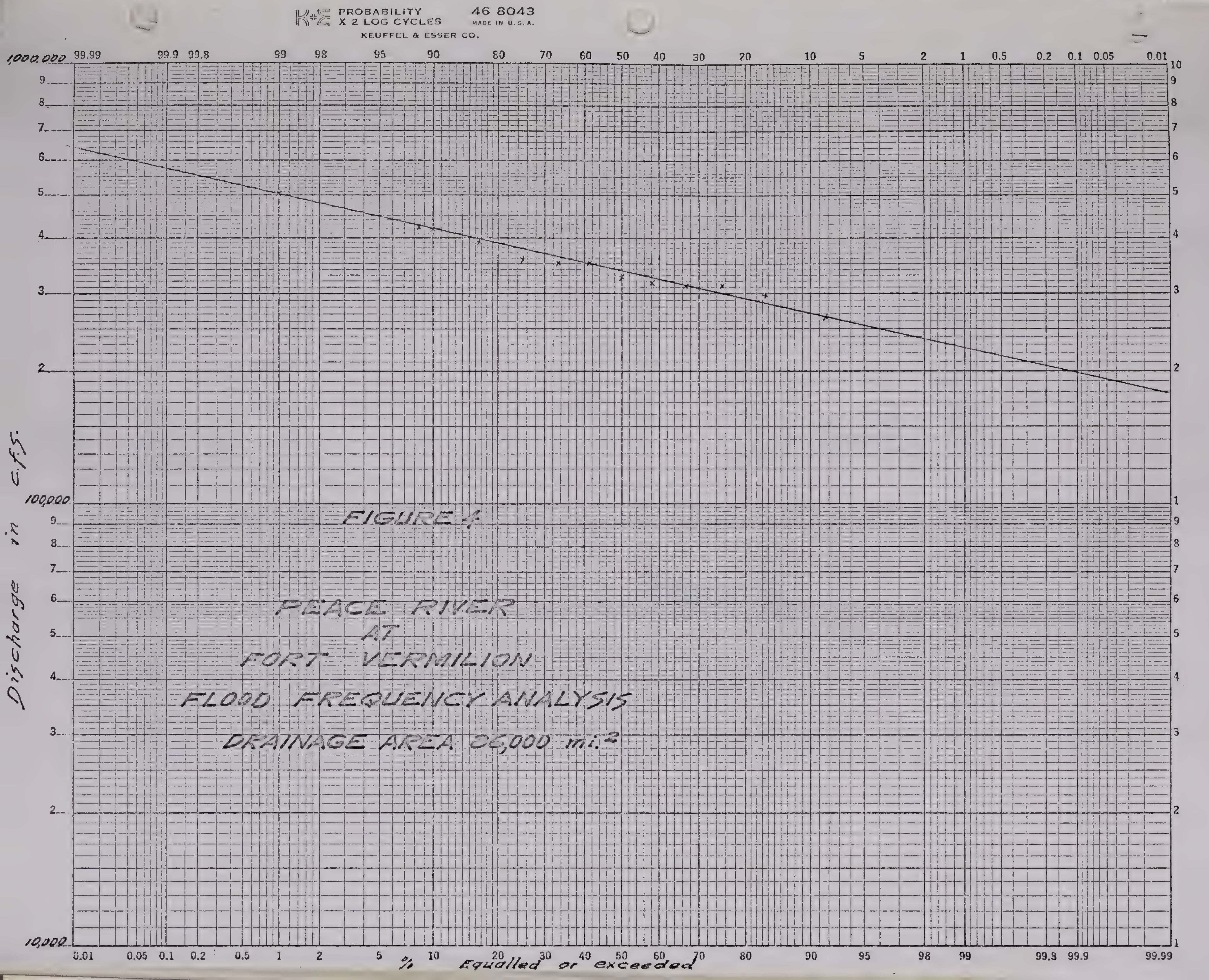

Peace River
A
B
C
D
E
FIG. 2
160-5807



Bankfull Widths
Peace River at Fort Vermilion

Scale
1" = 3333 Feet

Figure 3

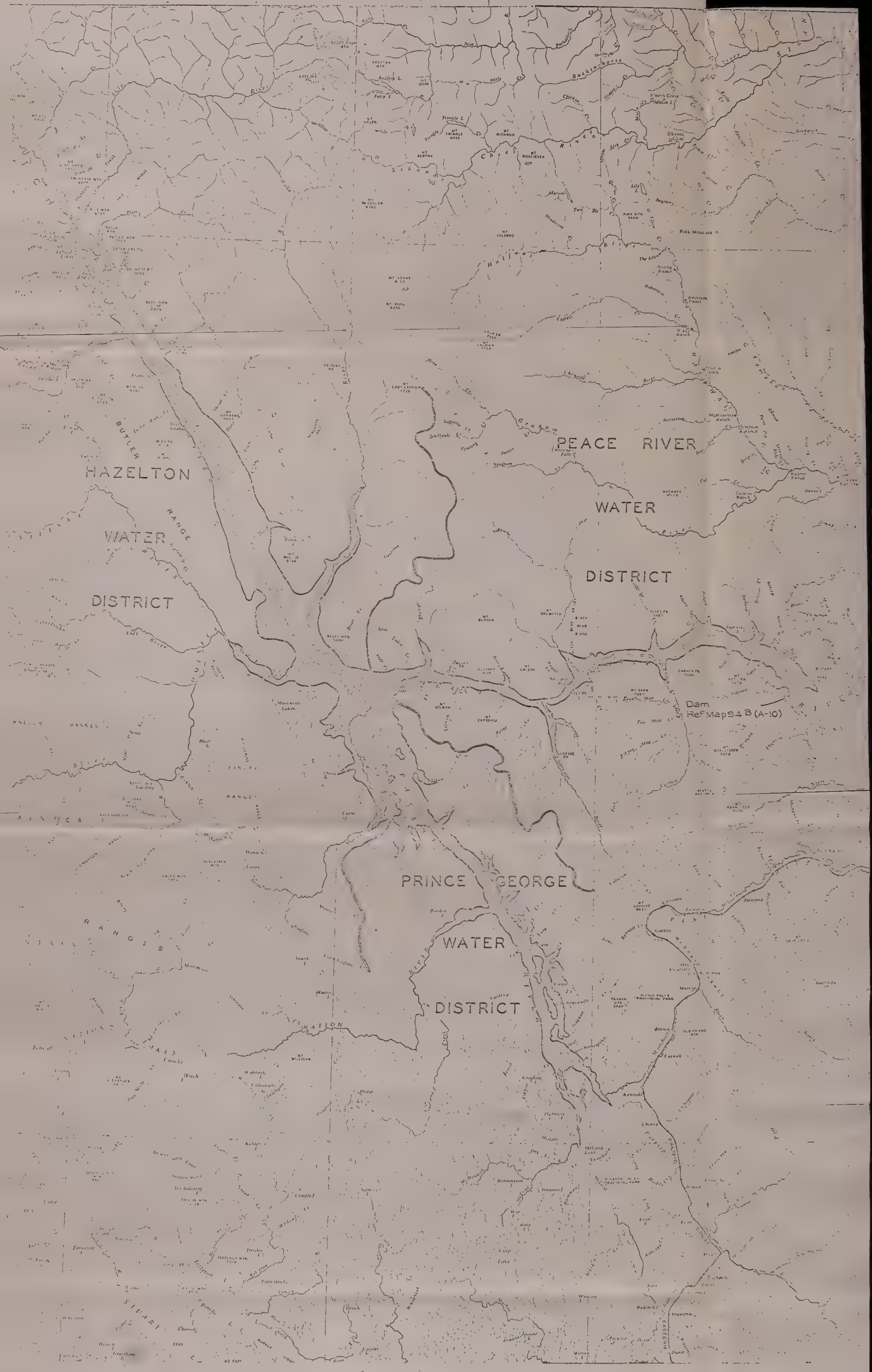

K+E PROBABILITY X 2 LOG CYCLES 46 8043 MADE IN U.S.A.
KEUFFEL & ESSER CO.
FIGURE 4
PEACE RIVER
AT
FORT VERMILION
FLOOD FREQUENCY ANALYSIS
DRAINAGE AREA 86,000 mi.²
Discharge in c.f.s.
% Equalled or exceeded
1,000,000
100,000
10,000

British Columbia

HAZELTON, PRINCE GEORGE &
PEACE RIVER WATER DISTRICTS

Scale: 10 Miles to 1 Inch

CARIBOO, CASSIAR & PEACE RIVER DISTRICTS.



LEGEND

Figure 5

Signature

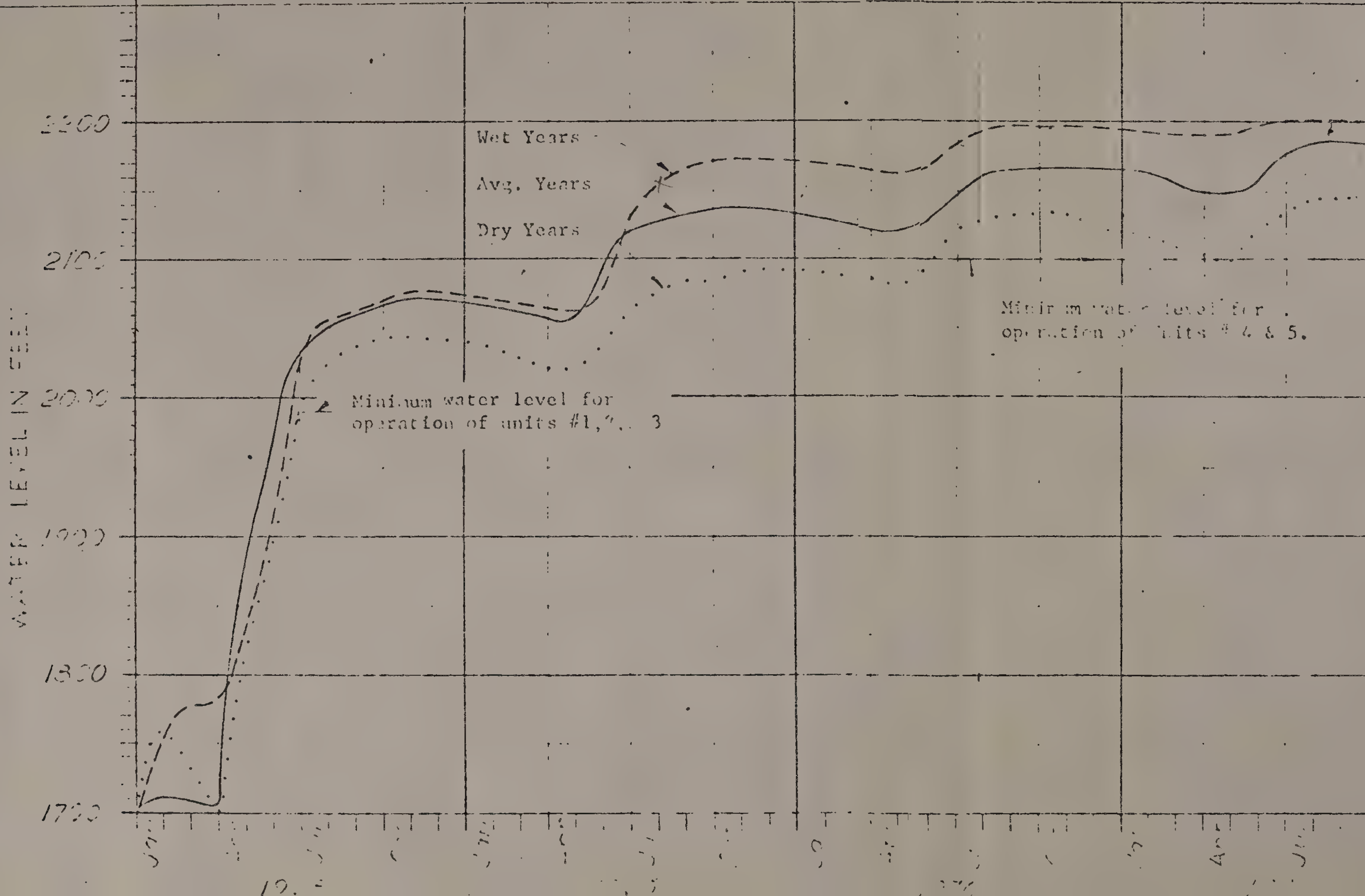
Date Dec. 21st 1962
C.L. 27722
File 0242651

EXHIBIT "A"

For Diversion see C.L 27721

Sequence of Wet years	1963	1963-64	1964-[illegible]	1965-66
Annual discharge M.A.F.	24.0	36.7	27.3	31.9 (Aug, Sept, est.)
Avg. power output MW		569	96[illegible]	1005
Sequence of Avg. years	1947	1947-48	1948-[illegible]9	1949-50
Annual discharge M.A.F.	22.9	27.7	26.4	27.4
Avg. power output MW		569	96[illegible]	1005
Sequence of Dry years	1943	1943-44	1944-45	1945-46
Annual discharge M.A.F.	19.2	21.9	23.4	22.9
Avg. power output MW		552* See Note 2	60[illegible]* See Note 2	1005

Outflow from reservoir	Compensation flows — Power flow from Oct. 1, 1968
Schedule of unit installation	Units #1, #2 — Unit #3 — Unit #4 — Unit #5



Monthly Average Power Output

	1968-69	1969-70	1970-71
July	-	608 MW	900* MW
August	-	608	1013*
September	-	810*	992*
October	410 MW	914*	996
November	540	932*	1013
December	540	921*	1013
January	540	960*	1013
February	540	1000*	1013
March	540	1013*	1013
April	540	852*	934
May	540	1013*	1013
June	608	1013*	1013

* See Note 2

Figure 6

NOTES

1. Monthly average power output from B.C.H.P.A. estimate dated June 28, 1966
2. For sequence of dry years average power output reduced to 608 MW (constant) from September 1969 through September 1970, inclusive, to facilitate reservoir filling

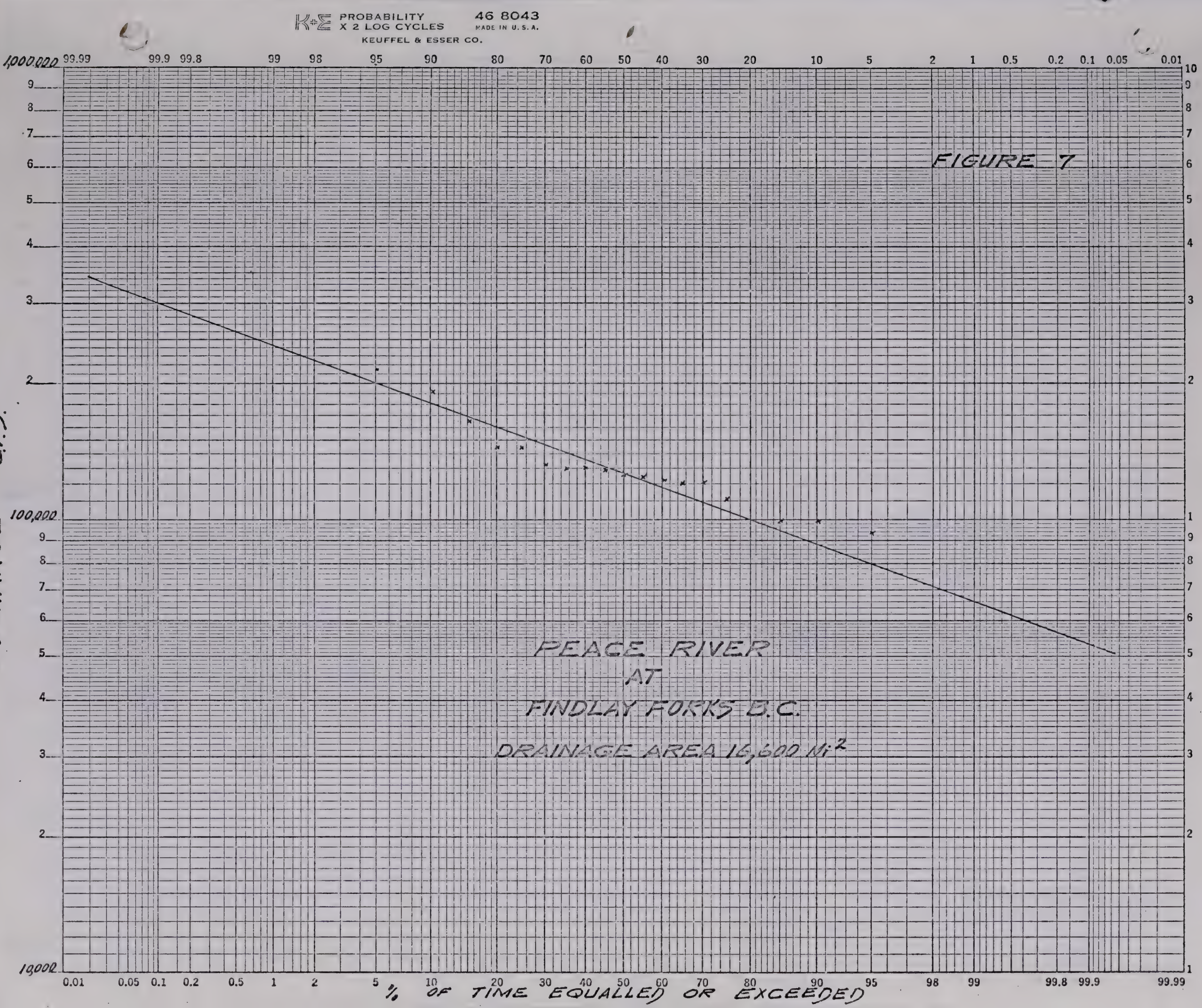
B.C. HYDRO & POWER AUTHORITY

PORTAGE MOUNTAIN DEVELOPMENT

RESERVOIR FILLING SEQUENCE OF WET AVERAGE & DRY YEARS

INTERNATIONAL POWER & ENGINEERING CONSULTANTS LTD VANCOUVER B.C.

IPEC No. B-3041-S13[illegible]



K+E PROBABILITY X 2 LOG CYCLES 46 8043 MADE IN U.S.A.
KEUFFEL & ESSER CO.
FIGURE 7
PEACE RIVER
AT
FINDLAY FORKS B.C.
DRAINAGE AREA 16,600 Mi.2
1,000,000
100,000
10,000
DISCHARGE - C.F.S.
% OF TIME EQUALLED OR EXCEEDED

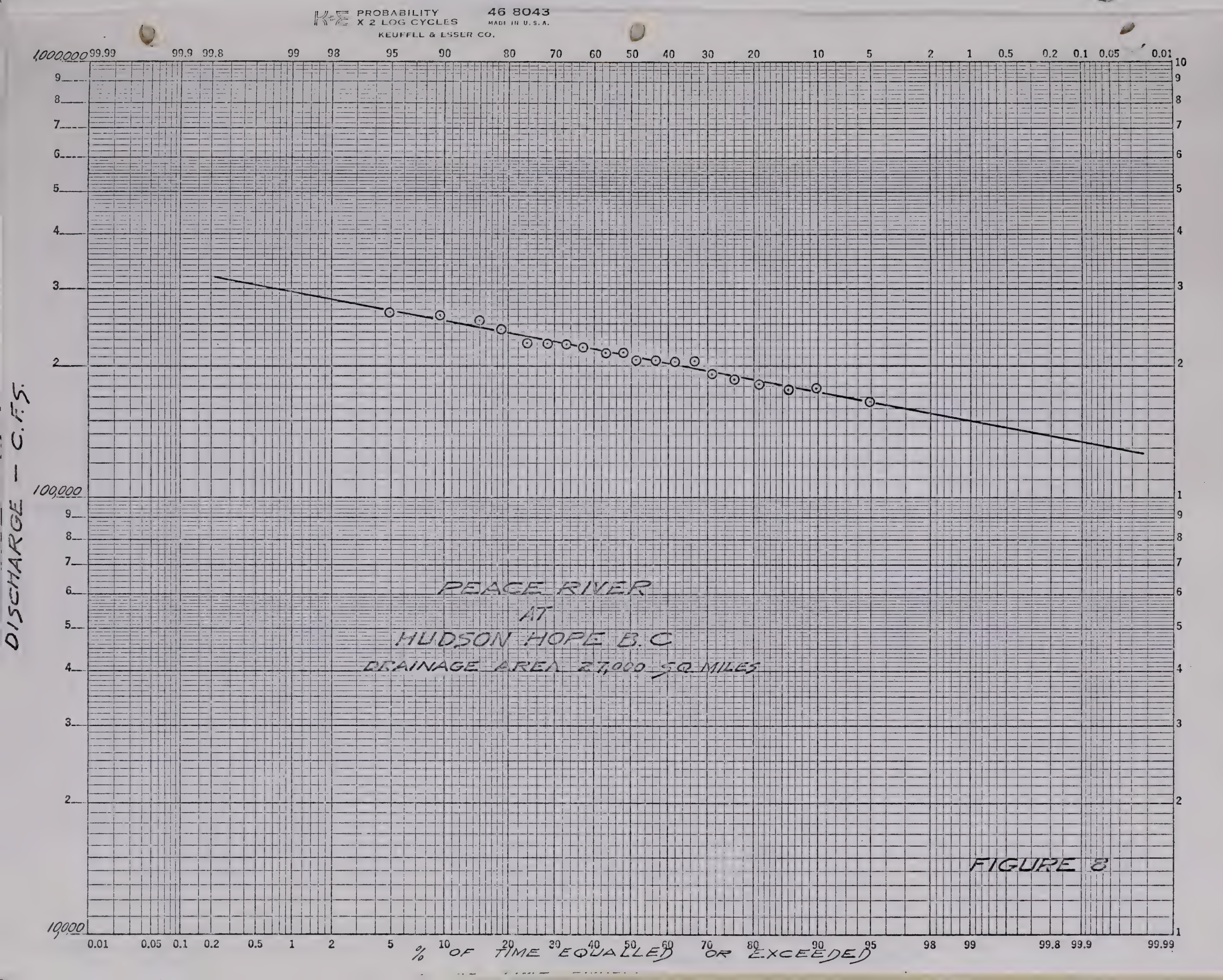
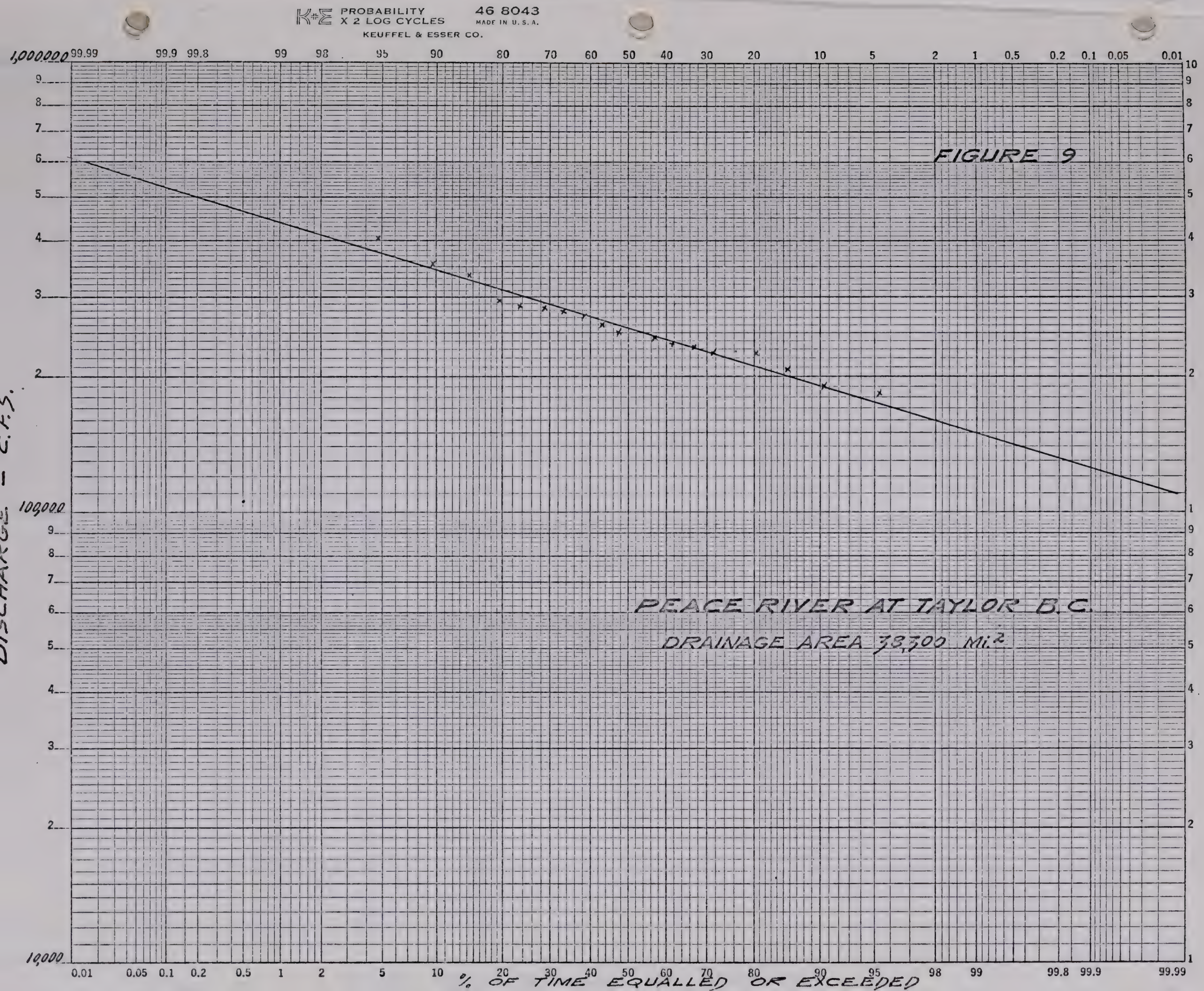
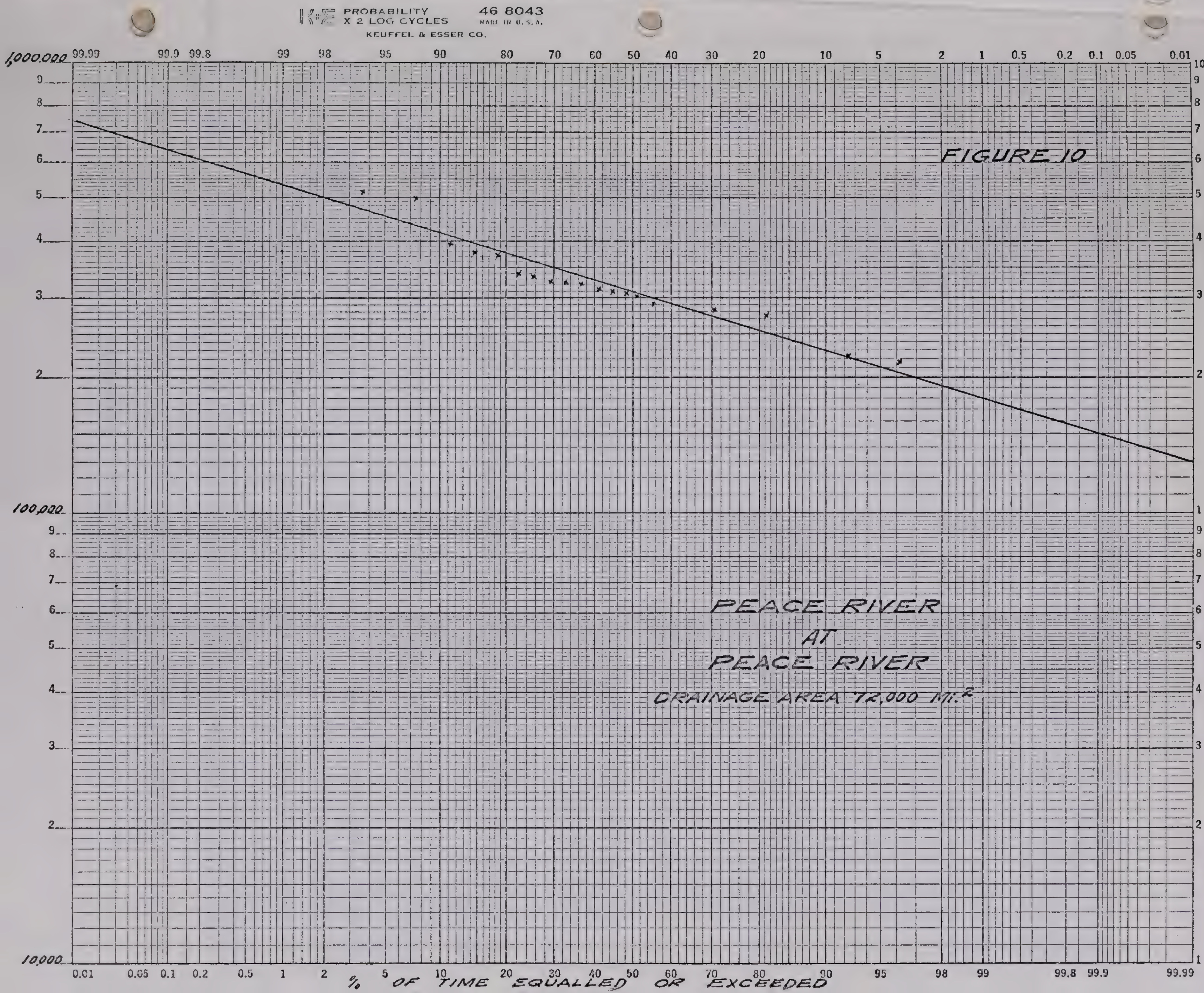

K+E PROBABILITY X 2 LOG CYCLES 46 8043 MADE IN U.S.A. KEUFFEL & ESSER CO.
PEACE RIVER
AT
HUDSON HOPE B.C
DRAINAGE AREA 27,000 SQ. MILES
DISCHARGE — C.F.S.
% OF TIME EQUALLED OR EXCEEDED
1,000,000
100,000
10,000

FIGURE 8

FIGURE 9

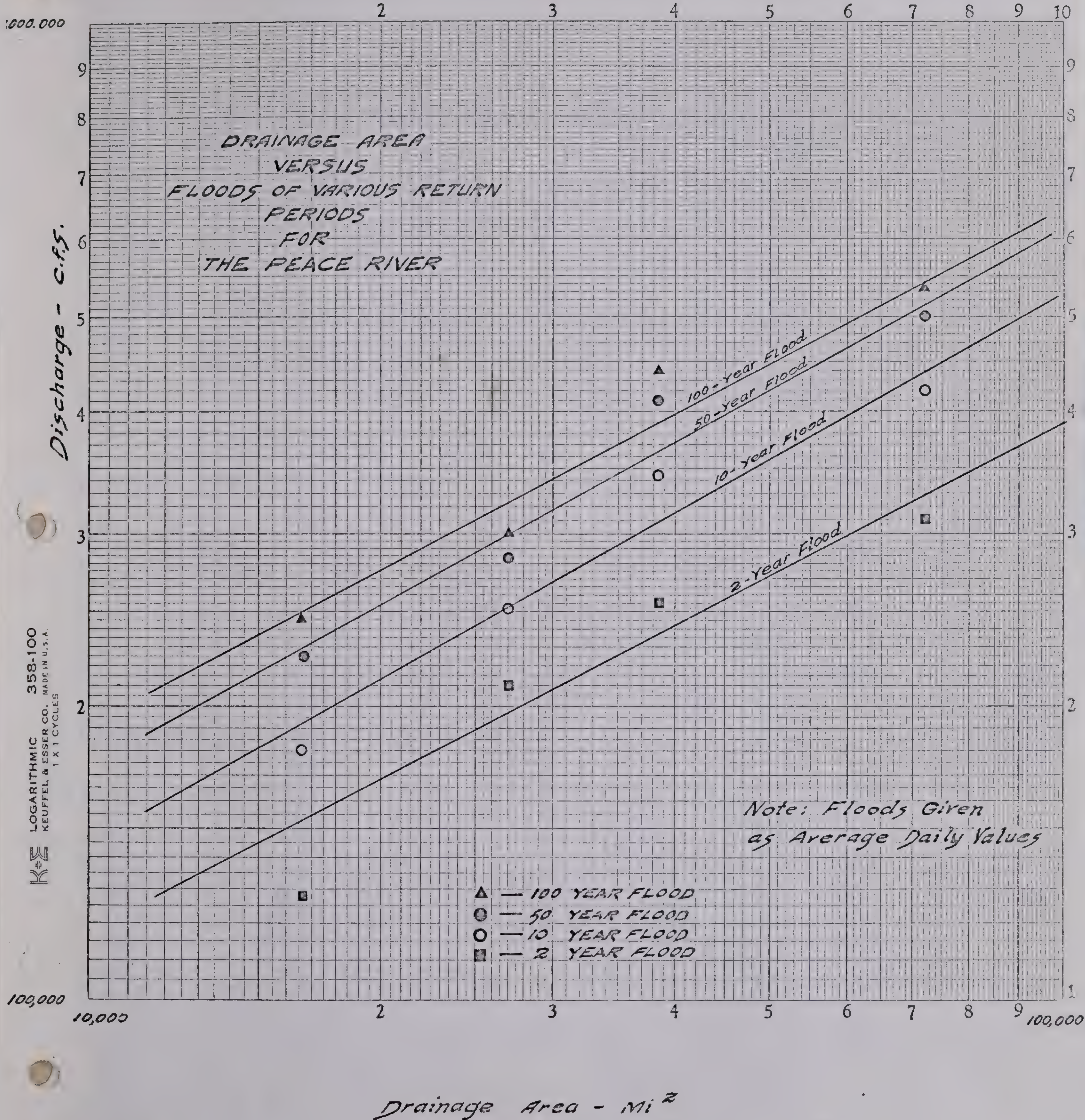


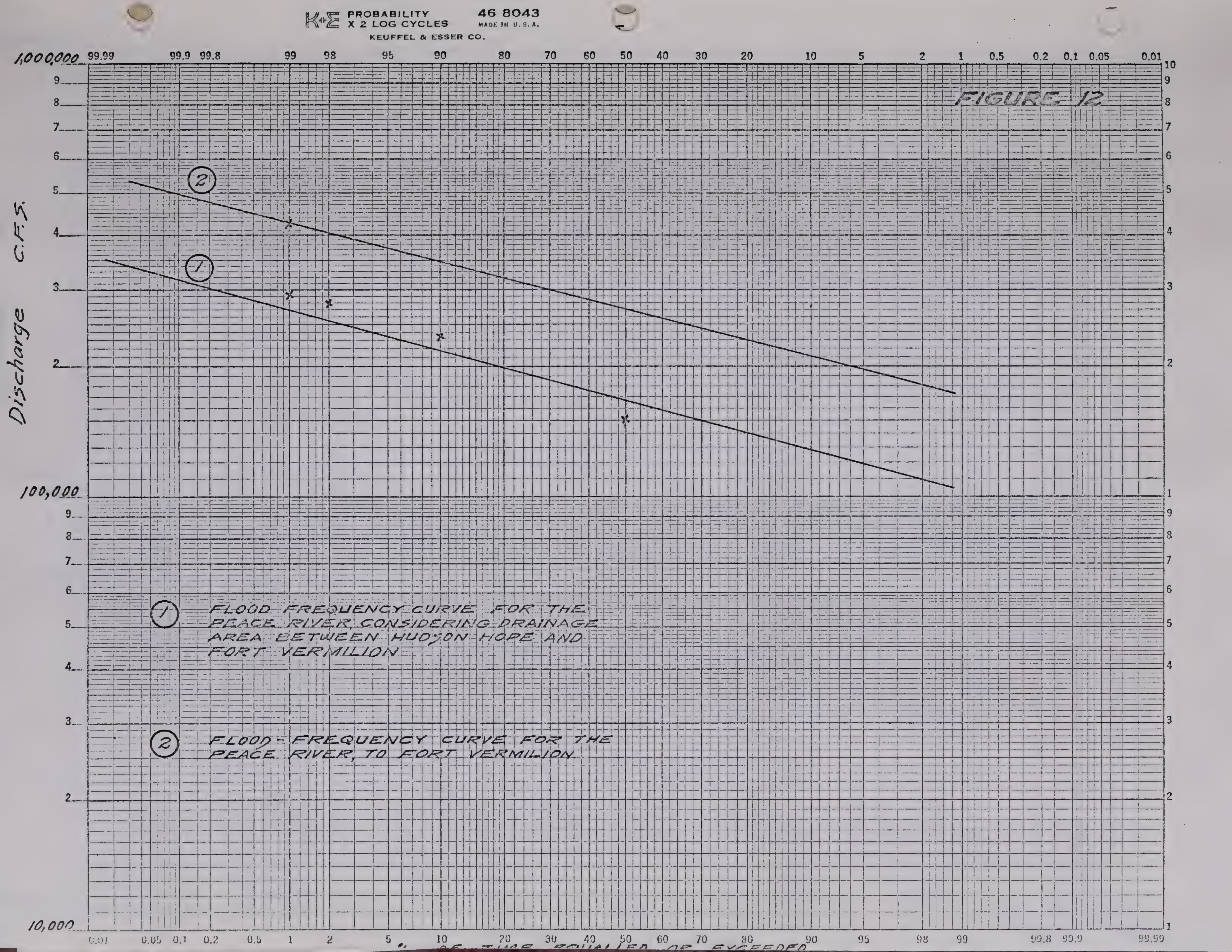
K+E PROBABILITY X 2 LOG CYCLES 46 8043 MADE IN U.S.A.
KEUFFEL & ESSER CO.
PEACE RIVER AT TAYLOR B.C.
DRAINAGE AREA 38,300 Mi.²
DISCHARGE - C.F.S.
% OF TIME EQUALLED OR EXCEEDED
1,000,000
100,000
10,000

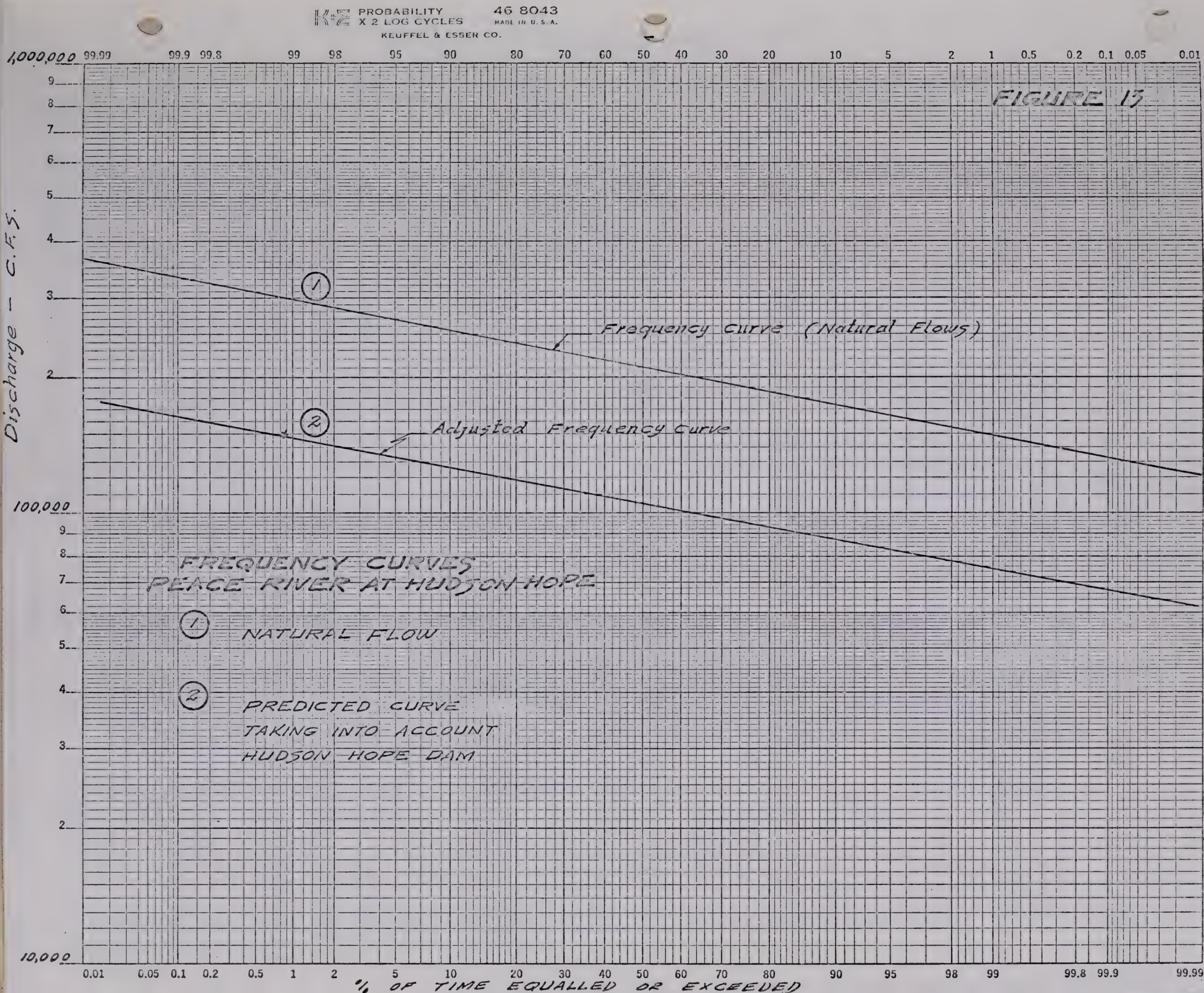


K+E PROBABILITY X 2 LOG CYCLES 46 8043 MADE IN U.S.A.
KEUFFEL & ESSER CO.
FIGURE 10
PEACE RIVER
AT
PEACE RIVER
DRAINAGE AREA 72,000 MI.^{2}
1,000,000
100,000
10,000
% OF TIME EQUALLED OR EXCEEDED

Figure II

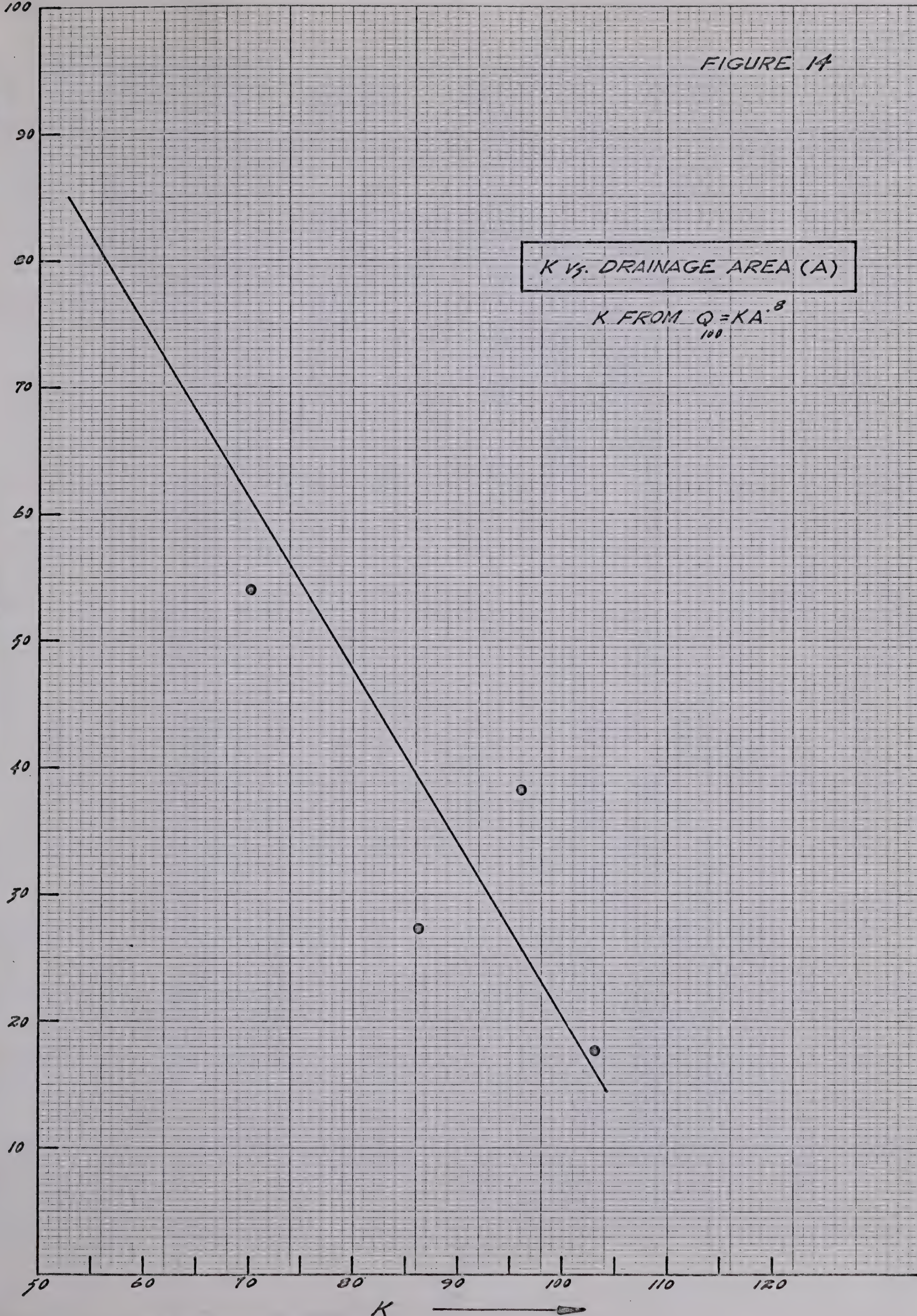

DRAINAGE AREA VERSUS FLOODS OF VARIOUS RETURN PERIODS FOR THE PEACE RIVER
Discharge - c.f.s.
Drainage Area - Mi²
1,000,000
100,000
10,000
100,000
100-Year Flood
50-Year Flood
10-Year Flood
2-Year Flood
Note: Floods Given as Average Daily Values
100 YEAR FLOOD
50 YEAR FLOOD
10 YEAR FLOOD
2 YEAR FLOOD
LOGARITHMIC 358-100
KEUFFEL & ESSER CO. MADE IN U.S.A.
1 X 1 CYCLES


K+E PROBABILITY X 2 LOG CYCLES 46 8043 MADE IN U.S.A.
KEUFFEL & ESSER CO.
FIGURE 12
Discharge C.F.S.
1,000,000
100,000
10,000
(1) FLOOD FREQUENCY CURVE FOR THE PEACE RIVER, CONSIDERING DRAINAGE AREA BETWEEN HUDSON HOPE AND FORT VERMILION
(2) FLOOD FREQUENCY CURVE FOR THE PEACE RIVER, TO FORT VERMILION

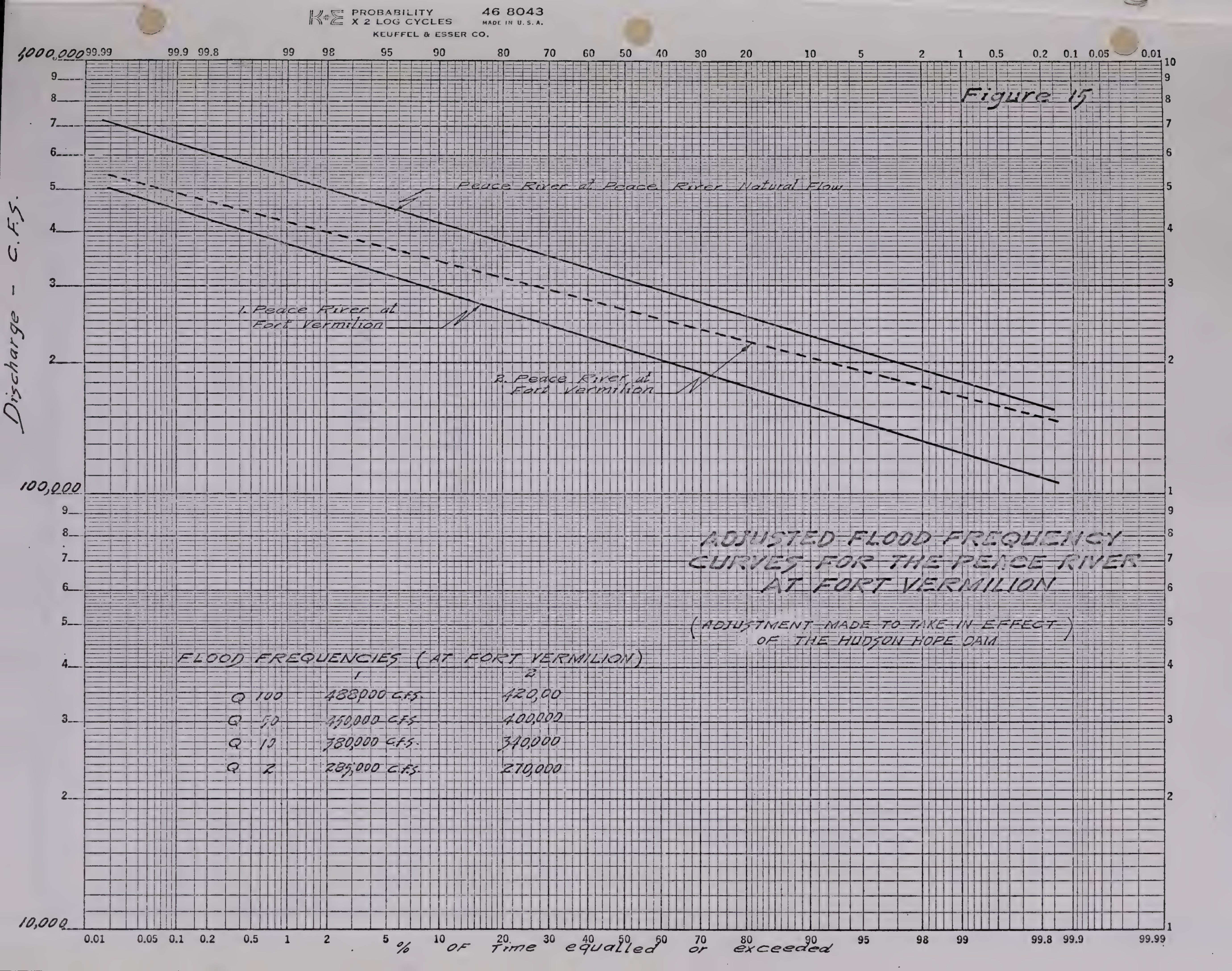


K+E PROBABILITY X 2 LOG CYCLES 46 8043 MADE IN U.S.A.
KEUFFEL & ESSER CO.
FIGURE 13
Frequency Curve (Natural Flows)
Adjusted Frequency Curve
FREQUENCY CURVES
PEACE RIVER AT HUDSON HOPE
1 NATURAL FLOW
2 PREDICTED CURVE TAKING INTO ACCOUNT HUDSON HOPE DAM
Discharge — C.F.S.
1,000,000
100,000
10,000
% OF TIME EQUALLED OR EXCEEDED

FIGURE 14



K Vs. DRAINAGE AREA (A)
K FROM $Q_{100} = KA^{.8}$
DRAINAGE AREA X 1000
100
90
80
70
60
50
40
30
20
10
50
60
70
80
90
100
110
120
K


K+E PROBABILITY X 2 LOG CYCLES 46 8043 MADE IN U.S.A.
KEUFFEL & ESSER CO.
Figure 15
Peace River at Peace River Natural Flow
1. Peace River at Fort Vermilion
2. Peace River at Fort Vermilion
ADJUSTED FLOOD FREQUENCY CURVES FOR THE PEACE RIVER AT FORT VERMILION
(ADJUSTMENT MADE TO TAKE IN EFFECT OF THE HUDSON HOPE DAM)
FLOOD FREQUENCIES (AT FORT VERMILION)
1 2
Q 100 488,000 C.F.S. 420,00
Q 50 450,000 C.F.S. 400,000
Q 10 380,000 C.F.S. 340,000
Q 2 285,000 C.F.S. 270,000
Discharge - C.F.S.
1000,000
100,000
10,000
% of Time equalled or exceeded

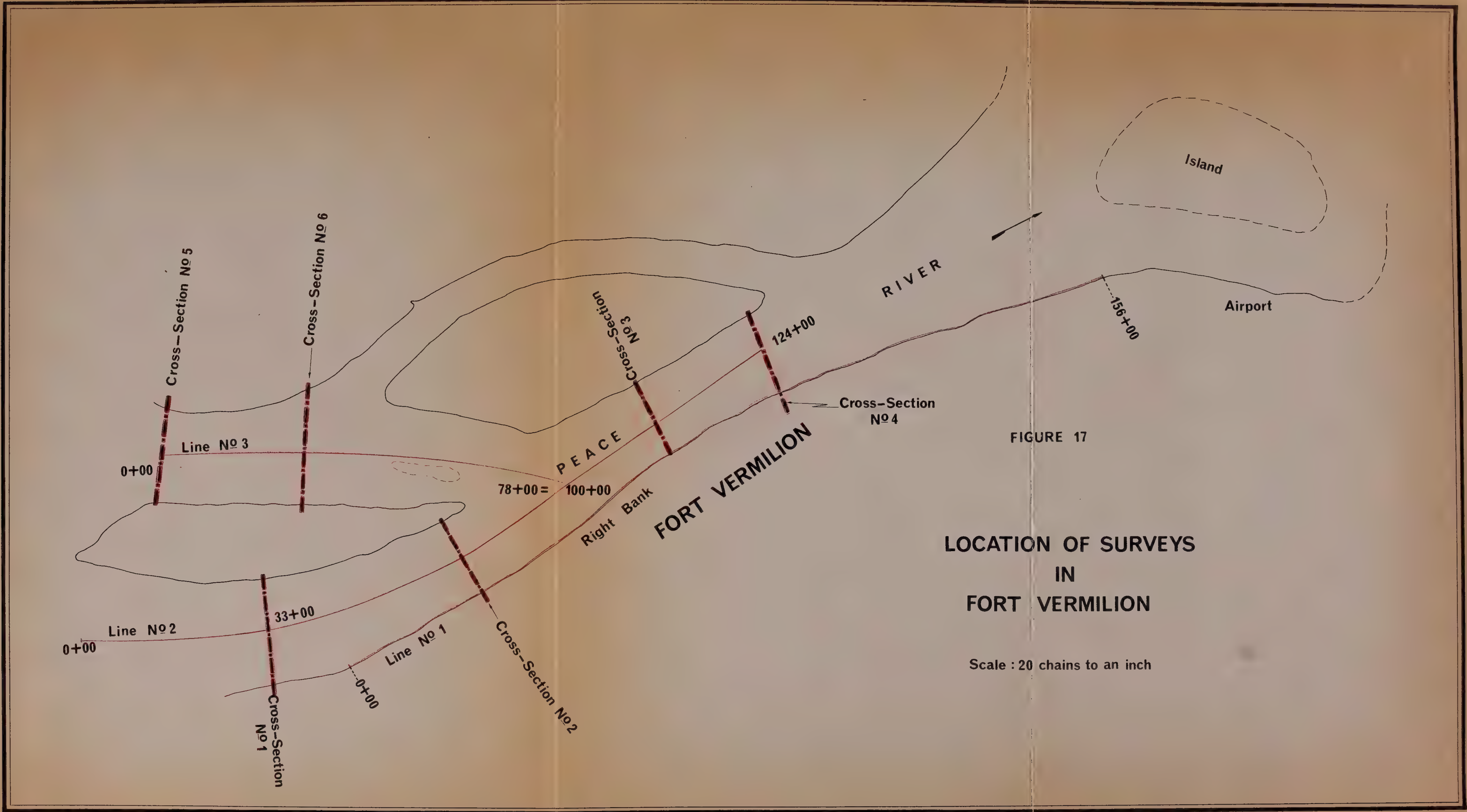


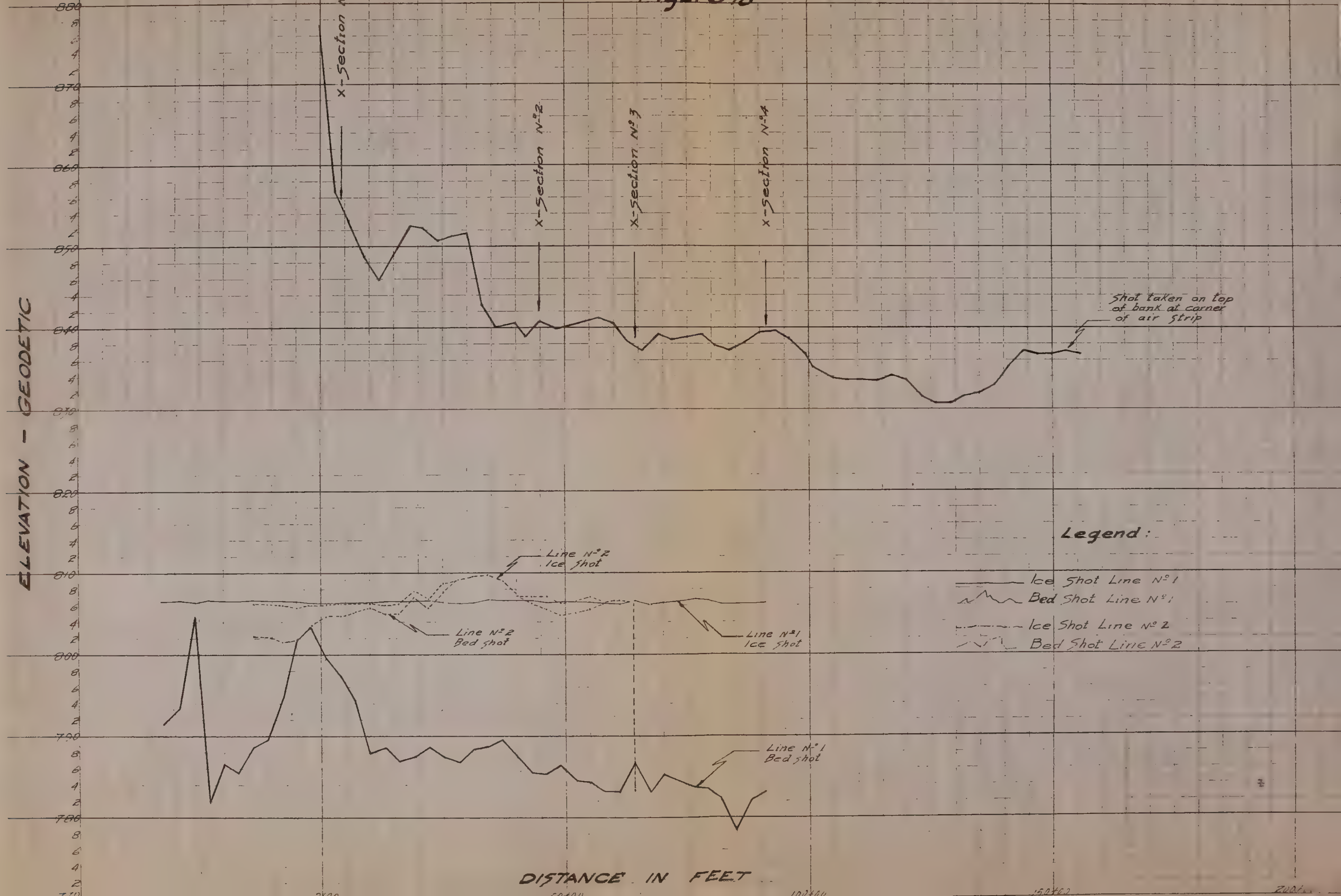
FIGURE 17

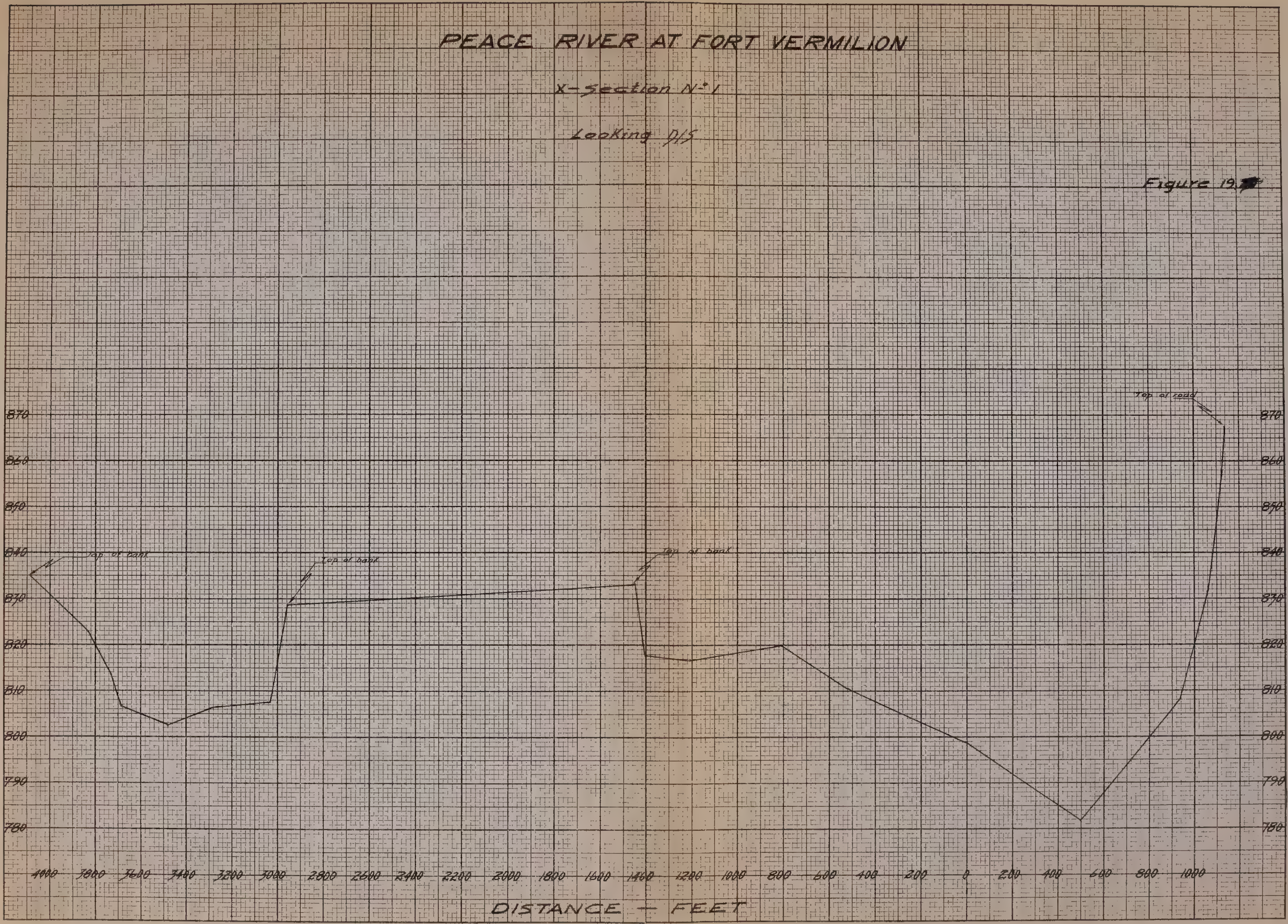
LOCATION OF SURVEYS
IN
FORT VERMILION

Scale : 20 chains to an inch

PROFILE OF RIGHT BANK OF PEACE RIVER AT FORT VERMILION

Figure 18




PEACE RIVER AT FORT VERMILION
X-Section N° 1
Looking D/S
Figure 19.
Top of bank
Top of bank
Top of bank
Top of road
ELEVATION (GEODETIC)
870
860
850
840
830
820
810
800
790
780
4000
3800
3600
3400
3200
3000
2800
2600
2400
2200
2000
1800
1600
1400
1200
1000
800
600
400
200
0
200
400
600
800
1000
DISTANCE — FEET

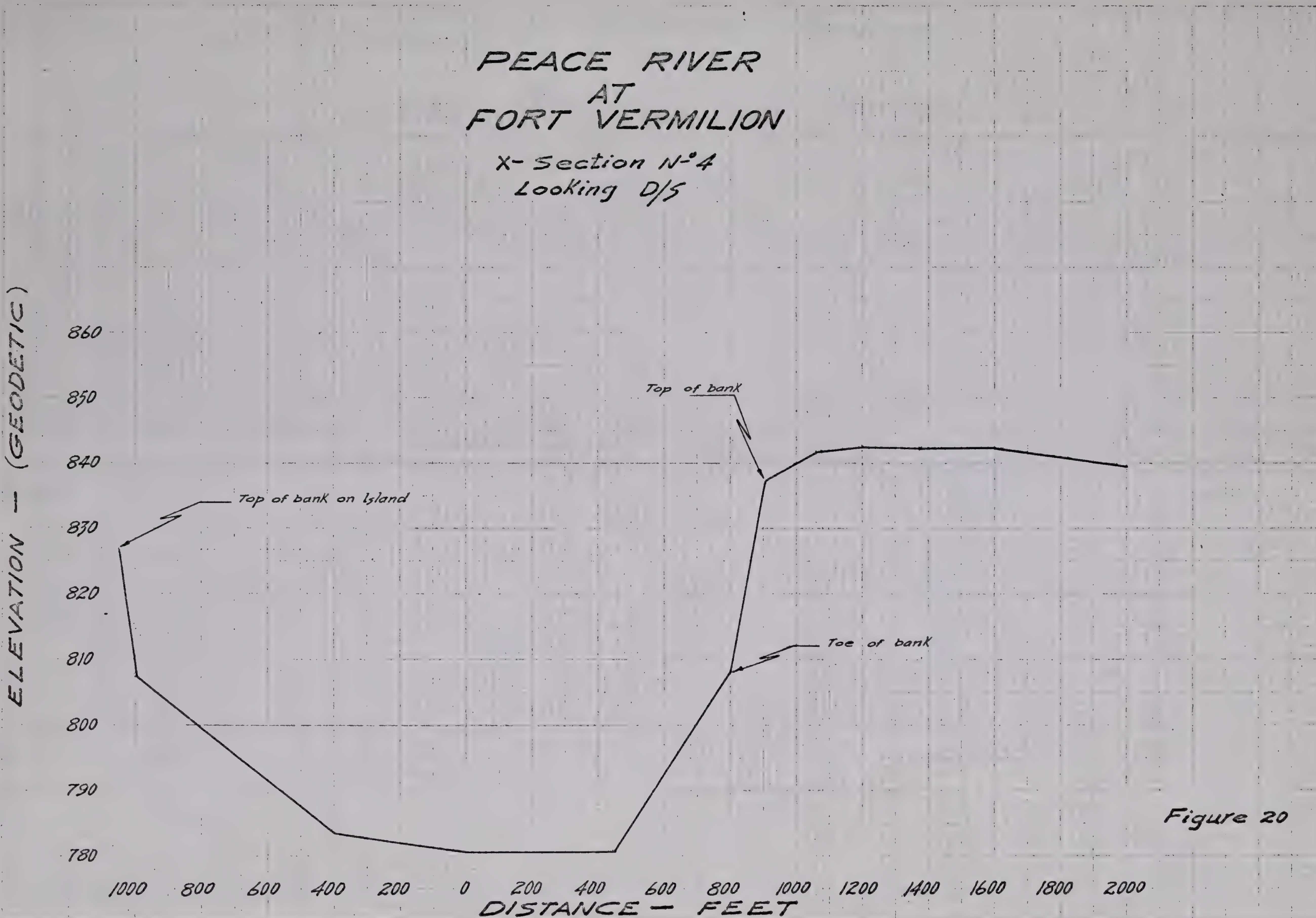

PEACE RIVER
AT
FORT VERMILION
X-Section N°4
Looking D/S
ELEVATION — (GEODETIC)
860
850
840
830
820
810
800
790
780
1000
800
600
400
200
0
200
400
600
800
1000
1200
1400
1600
1800
2000
DISTANCE — FEET
Top of bank on Island
Top of bank
Toe of bank

Figure 20

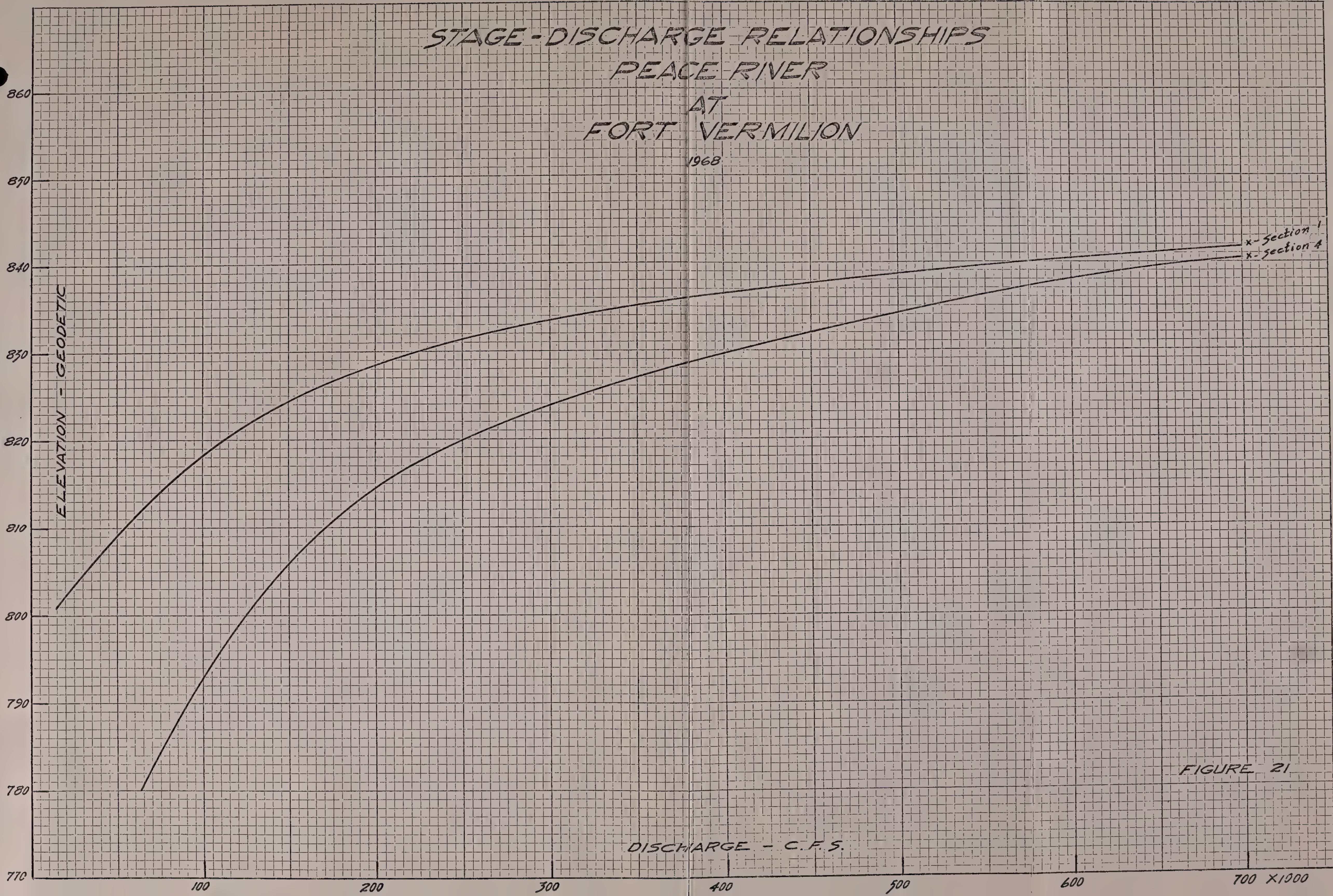

STAGE - DISCHARGE RELATIONSHIPS
PEACE RIVER
AT
FORT VERMILION
1968
ELEVATION - GEODETIC
860
850
840
830
820
810
800
790
780
770
x - Section 1
x - Section 4
DISCHARGE - C.F.S.
100
200
300
400
500
600
700 X1000

FIGURE 21

APPENDIX B

TABLES

TABLE 1

ANNUAL FLOOD PEAKS - PEACE RIVER

Location	Findlay Forks B. C.	Hudson Hope B.C.	Taylor B.C.	Peace River Alberta	Fort Vermilion
Year					
1915				338,850	
1916				261,785	
1917		168,350		221,314	298,646
1918		226,660		282,928	391,000
1919		227,500		304,700	317,940
1920		209,356		337,350	351,150
1921		254,716		309,460	316,800
1922		266,560		374,480	326,600
1923				291,000	
1924				281,000	
1925				275,000	
1926				289,000	
1927				310,000	
1928				236,000	
1929				218,000	
1930				327,000	
1931				277,000	
1945			228,000		
1946	124,000		237,000		
1947	126,000		226,000		
1948	217,000		407,000		
1949	94,100		190,000		
1950	148,000	240,000	243,000		
1951	100,000	183,000	183,000		
1952	122,000	187,000	208,000		
1953	122,000	217,000	286,000		
1954	133,000	222,000	333,000		
1955	147,000	216,000	279,000		
1956	100,000	179,000	231,000		

TABLE 1 cont.

Location	Findlay Forks B.C.	Hudson Hope B.C.	Taylor B.C.	Peace River Alberta	Fort Vermilion
Year					
1957	131,000	206,000	274,000		
1958	133,000	223,000	281,000	397,100	
1959	111,000	190,000	247,000	289,300	
1960	135,000	209,000	250,000	326,000	
1961	168,000	264,000	299,000	376,800	350,200
1962	128,000	208,000	260,000	323,000	314,000
1963	100,000	177,000	228,000	314,000	228,000
1964	193,000		353,000	498,000	421,000
1965				514,000	359,000
1966				296,000	263,000

APPENDIX C

PHOTOGRAPHS

PHOTO 1

1934 FLOOD IN FORT VERMILION

VIEW OF HUDSONS BAY COMPANY BUILDINGS PROBABLY VIEWED FROM POINT D, FIGURE 16.

PHOTO 2

THIS PHOTO PROVIDES A GOOD IDEA OF THE SIZE OF FORCES AT WORK DURING AN ICE JAM

PHOTO 3

RIGHT BANK IN FRONT OF HUDSONS BAY COMPANY STORE
THIS LENGTH OF BANK HAS ERODED ABOUT 21 FEET SINCE 1906

PHOTO 4

SAME LENGTH OF BANK AS ABOVE VIEWED FROM RIVER.
HUDSONS BAY STORE IN BACKGROUND
NOTE SPARSE TREE GROWTH

PHOTO 5

LOOKING UPSTREAM ON THE PEACE RIVER AT FORT VERMILION
NOTE TYPE OF VEGETATION ON RIGHT BANK

PHOTO 6

LOOKING DOWNSTREAM ON THE PEACE RIVER AT FORT VERMILION
NOTE SPARSE TREE GROWTH ON RIGHT BANK

APPENDIX D

MEMOS

DEPARTMENT OF MUNICIPAL AFFAIRS

300-I.D. 147

Noel Dant
Provincial Planning Director
Department of Municipal Affairs

R. E. Bailey, Director
Water Resources Branch
Department of Agriculture

June 9th. 1957

Re: Fort Vermilion

We are at the present time engaged in a study leading towards a replotting scheme of the above settlement.

It has been indicated to us by residents in the area that there exists a flooding problem at periodic intervals. We would be pleased to receive from you at your earliest convenience, a report on what areas are subject to flooding and an indication of the water table for the areas under Titles 185-B-187 and 112-W-112. A map of the area we have under consideration is enclosed for your convenience.

Noel Dant

NOEL DANT
Provincial Planning Director

KG/mrk
enclosure

PROVINCE OF ALBERTA

MEMORANDUM DEPARTMENT OF MUNICIPAL AFFAIRS

OUR FILE NO.: 300-I.D. 147

YOUR FILE NO.:

FROM: Noel Dant
Provincial Planning Director
Department of Municipal Affairs

TO: R. E. Bailey, Director
Water Resources Branch
Department of Agriculture

DATE: October 24th, 1967

Re: Fort Vermilion

With regard to our memorandum dated June 9th, 1967, a copy of which is attached hereto, we would appreciate receiving a reply at your earliest possible convenience.

D. A. WATTERS
(for) Provincial Planning Director

/mrk
attach.

ITEM 187

PROVINCE OF ALBERTA

MEMORANDUM DEPARTMENT OF MUNICIPAL AFFAIRS

OUR FILE NO.: 300-I.D. 147

YOUR FILE NO.:

FROM: Noel Dant
Provincial Planning Director
Department of Municipal Affairs

TO: L. D. M. Sadler
Branch Head
Soils Geology & Groundwater Branch
Department of Agriculture

DATE: June 9th, 1967

Re: Fort Vermilion

We are at the present time engaged in a study leading towards a replotting scheme of the above settlement.

It has been indicated to us by residents in the area that there is a definite erosion problem on the bank of the Peace River adjacent to the settlement. Since the stability of the bank will affect the design of our proposed scheme, I would appreciate receiving from you a report on the stability of the said river bank and the feasibility of locating a major road along its edge. A plan of the area we have under consideration is enclosed for your convenience. Your early attention to this matter would be appreciated.

Noel Dant.
NOEL DANT
Provincial Planning Director

KG/mrk
enclosure

PROVINCE OF ALBERTA

MEMORANDUM DEPARTMENT OF MUNICIPAL AFFAIRS

OUR FILE NO.: 300-I.D. 147

YOUR FILE NO.:

FROM: Noel Dant
Provincial Planning Director
Department of Municipal Affairs

TO: W. D. M. Sadler, Branch Head
Soils Geology and Groundwater Branch
Department of Agriculture

DATE: October 24th, 1967

Re: Fort Vermilion

With regard to our memorandum to you dated June 9th, 1967, a copy of which is attached hereto, we would appreciate receiving a reply at your earliest convenience.

(for) D. A. WATTERS
Provincial Planning Director

/mrk
attach.

Figure 16


Peace River
FIGURE 16
FORT VERMILION
Area Flooded
CONTOUR
DEPRESSION CONTOUR
LAKE RIVER OR STREAM
INTERMITTENT STREAM OR SLOUGH
TREES
BUILDINGS
FENCE
CONTROL POINTS
1st CLASS ROAD
2nd CLASS ROAD
3rd CLASS ROAD
TRAIL
GRAVEL PIT OR MINE
A. S. PROJECT No. 26/66
Compiled by Photogrammetric Methods from Air Photographs taken in 1966
AERIAL SURVEYS SECTION
TECHNICAL DIVISION
DEPT. OF LANDS & FORESTS
SCALE: 1 in = 200 ft.
ELEVATIONS ARE GEODETIC
DATED DEC 13, 1966
CONTOUR INTERVAL 2½ ft.


Peace River
FIGURE 16
FORT VERMILION
Area Flooded
CONTOUR
DEPRESSION CONTOUR
LAKE RIVER OR STREAM
INTERMITTENT STREAM OR SLOUGH
TREES
BUILDINGS
FENCE
CONTROL POINTS
1st CLASS ROAD
2nd CLASS ROAD
3rd CLASS ROAD
TRAIL
GRAVEL PIT OR MINE
A. S. PROJECT No. 26/66
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CONTOUR INTERVAL 2½ ft.